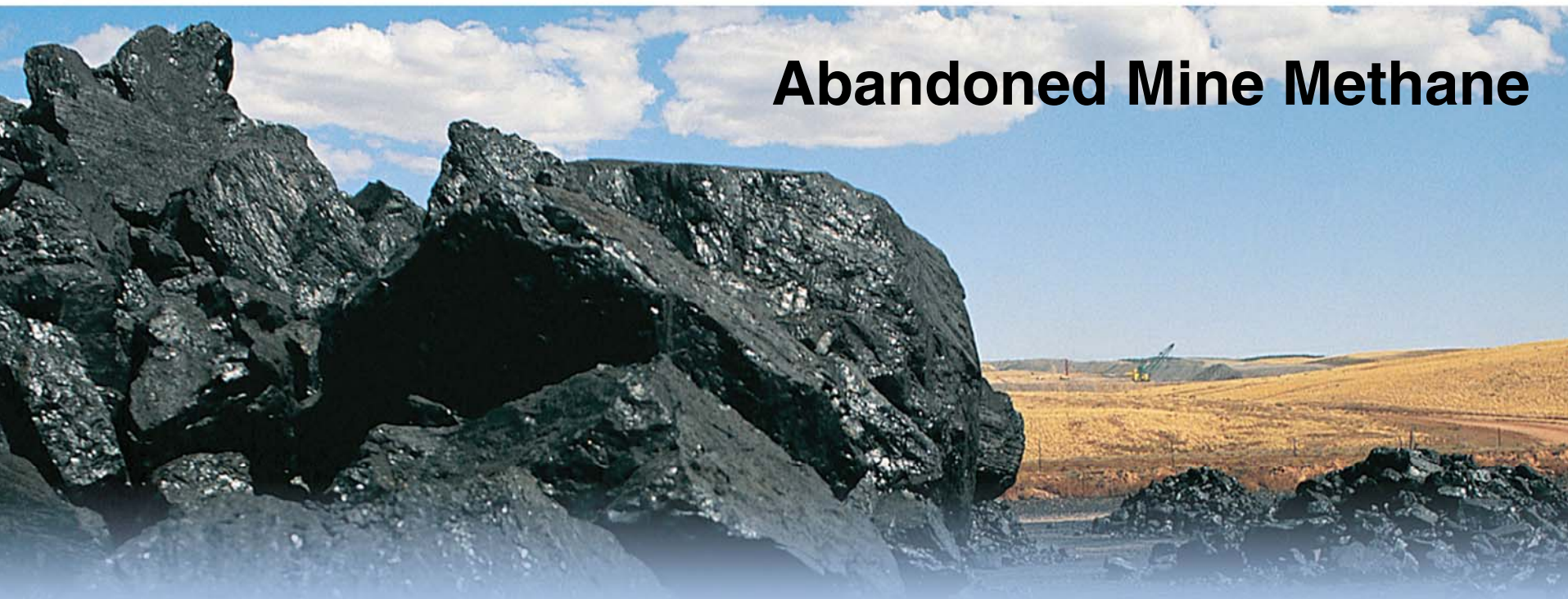


Coal Mine Methane Recovery & Utilization:



Abandoned Mine Methane



Jayne Somers, Ph.D., P.E.
US Environmental Protection Agency

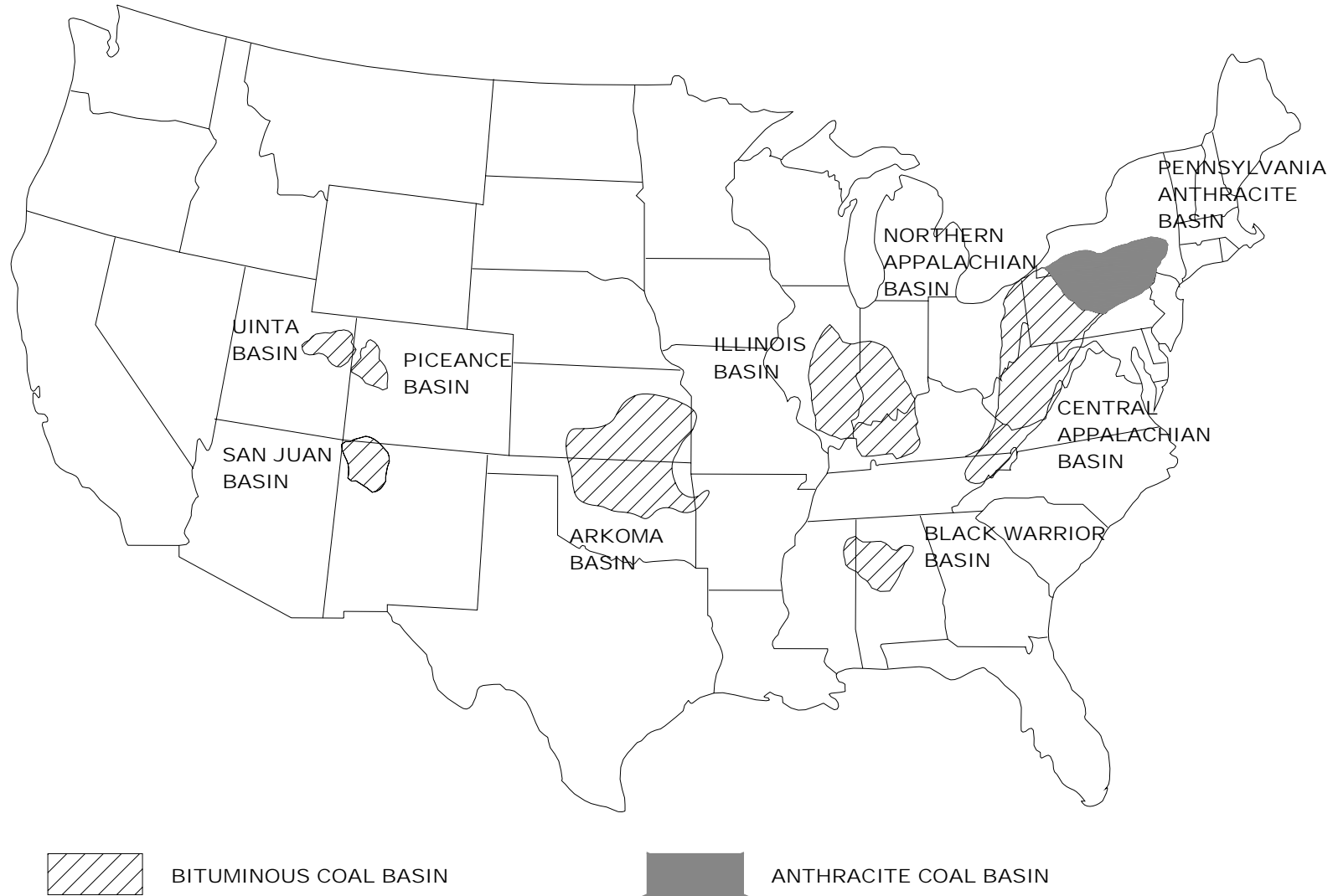


Pittsburgh, PA
October 29, 2008

Presentation Outline

- AMM Background
- AMM Case Studies
 - Greyson Hill Energy
 - Kings Station
 - DTE
- Factors Influencing AMM Emissions
- AMM Project Opportunities
- AMM Methodology
- Conclusions

U.S. Gassy Coal Basins with Underground Coal Mines



U.S. Abandoned Mine Methane (AMM)

- AMM emissions: 13.4 bcf (2006)
- AMM: 3.4 bcf recovered and utilized ₍₂₀₀₆₎ = 25% of total
- 33 US abandoned mine projects with varied end-uses
- Many are located in Illinois basin

Breakdown of AMM Projects by Coal Basin and State

Coal Basin	State	Number of Abandoned Mines with Recovery
Central Appalachian	Virginia	5
Northern Appalachian	Ohio	2
Northern Appalachian	Pennsylvania	1
Northern Appalachian	West Virginia	6
Raton	Colorado	1
Illinois	Illinois	27
Illinois	Indiana	1
Warrior	Alabama	1
Total		44

Grayson Hill Energy Project

- AMM recovery and utilization project in Saline Co., IL developed by Grayson and Itera Intl. Energy Corp.
- Recovers methane from eight abandoned mines
- Began as an electric power project selling to local grid & utilizing waste heat for hydroponic greenhouses
- Market conditions for produce made the project unprofitable, leading Grayson Hill Energy to look to the closely located 24" Texas Eastern Pipeline
- Gas has been produced and sold to the Texas Eastern Pipeline since 2003

Grayson Hill Energy Project

- Electric power generation from two 750 kw generators onsite operate the project's gas processing plant
- A 2,500 mcf/d molecular sieve nitrogen rejection unit operates at the project's processing plant
- Approximately 1.0 mmcf/d of 96% methane gas is processed from the plant and sold

Kings Station Mine Project

- AMM recovery and utilization project operating in Gibson County, IN
- The project, developed by Roy Farmer and C.A. Robinson, sells upgraded AMM from the Kings Station Mine to an adjacent Toyota truck plant
- The mine was abandoned in 1973 and some areas of the mine are flooded, however two drainage wells are drilled into dry areas of the mine
- A gas processing plant was constructed for the two drainage wells, which produce a cumulative of 150-200mcf/d of gas from the mine, consisting of 920-930 BTU gas (6% CO₂ and 1% N₂)

Kings Station Mine Project

- The AMM is upgraded to 1,000 BTU by adding propane before it is sent to the truck plant by pipeline
- The nearby truck plant provided an ideal opportunity for gas sales
- The project has a contract with the Toyota plant requiring the project to supply a minimum of 10% of their daily requirement, which is presently 5 mmcf/d

King Station Project with End-User in Background



James Pena, 2007

DTE Methane Resources Project

- DTEMR project recovers methane from 11 abandoned mines in Franklin County, IL
- Complex of several mines in close proximity to each other, as well as nearby pipeline access, make this pipeline sales project successful.
- Mine gas is delivered to the DTEMR-operated Corinth Gas Plant by a 29 mile gas line with several compressor stations along the way.

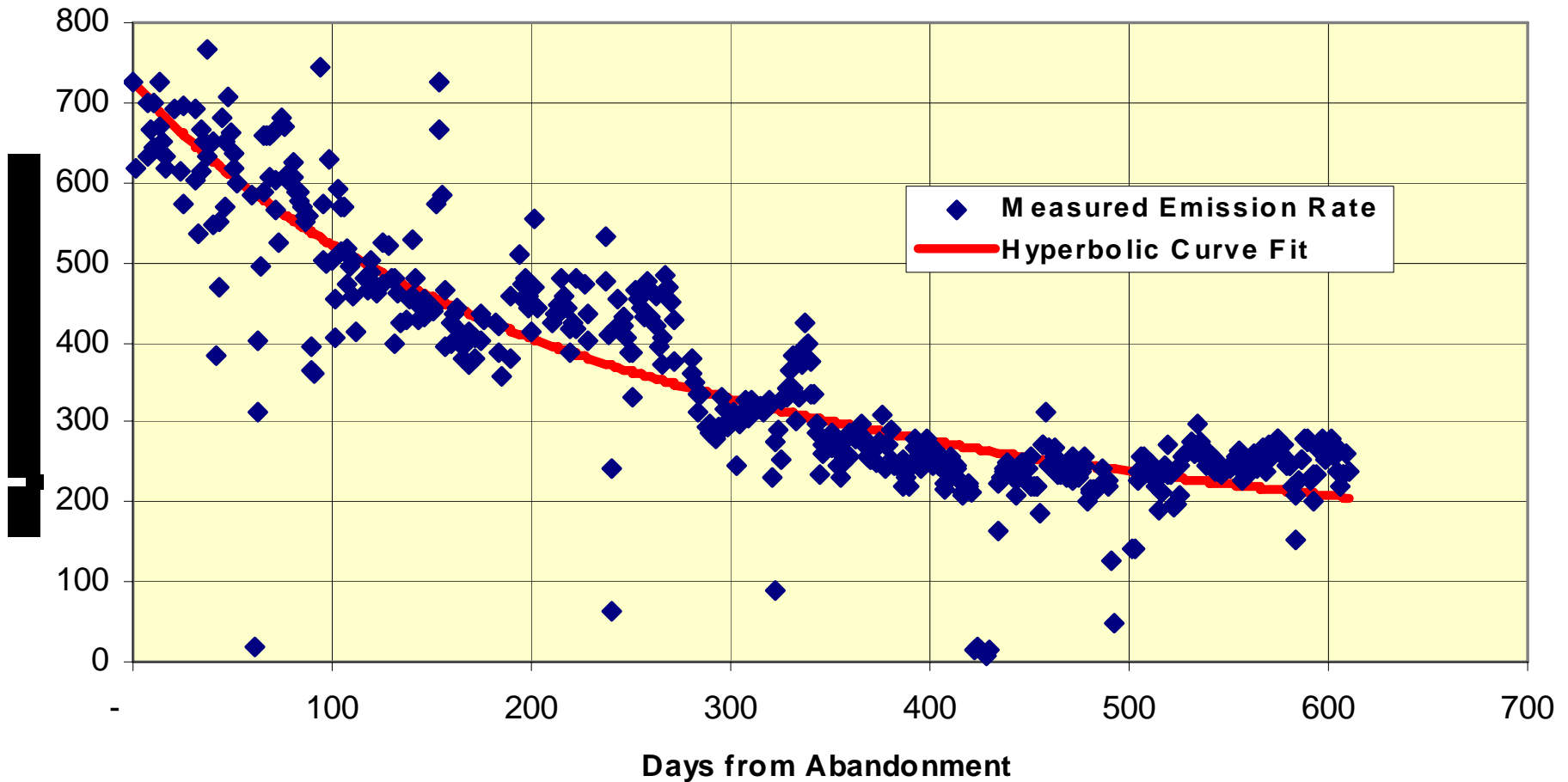
DTE Methane Resources Project

- The mine gas produced from 16 wells out of the 11 mines is on average 750 BTU with 17% N_2 and 9% CO_2
- DTE uses a BCCK nitrogen rejection unit to strip N_2 and CO_2 from the mine gas and bring it to pipeline quality.
- Product gas is sold to the Trunkline Gas Company's pipeline which is approximately one half mile from the plant.

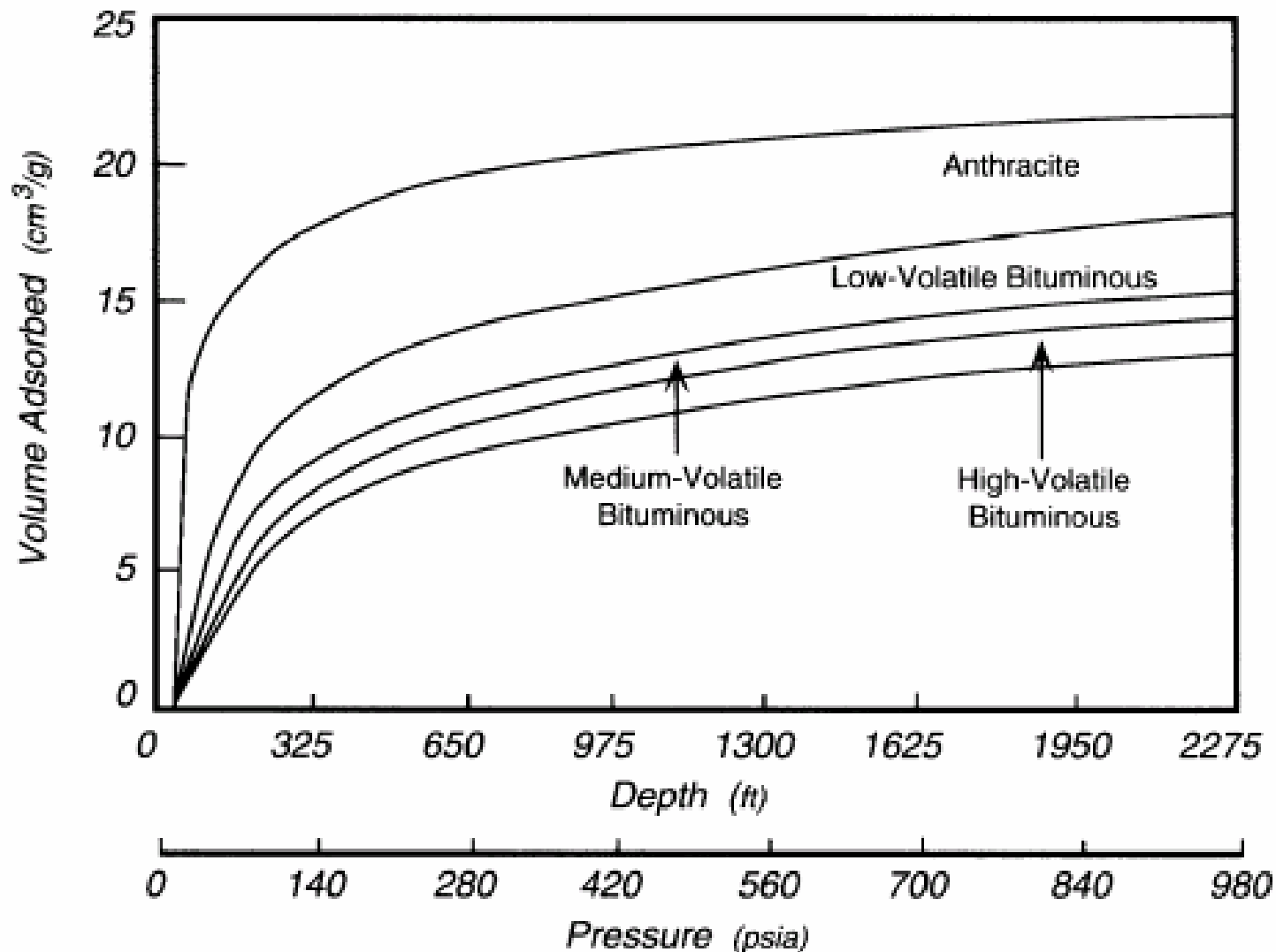
Factors Influencing Abandoned Mine Emissions

- Time since abandonment
- Gas content & adsorption characteristics of coal
- CH₄ flow capacity of mine
- Mine flooding
- Presence of vent holes
- Mine seals

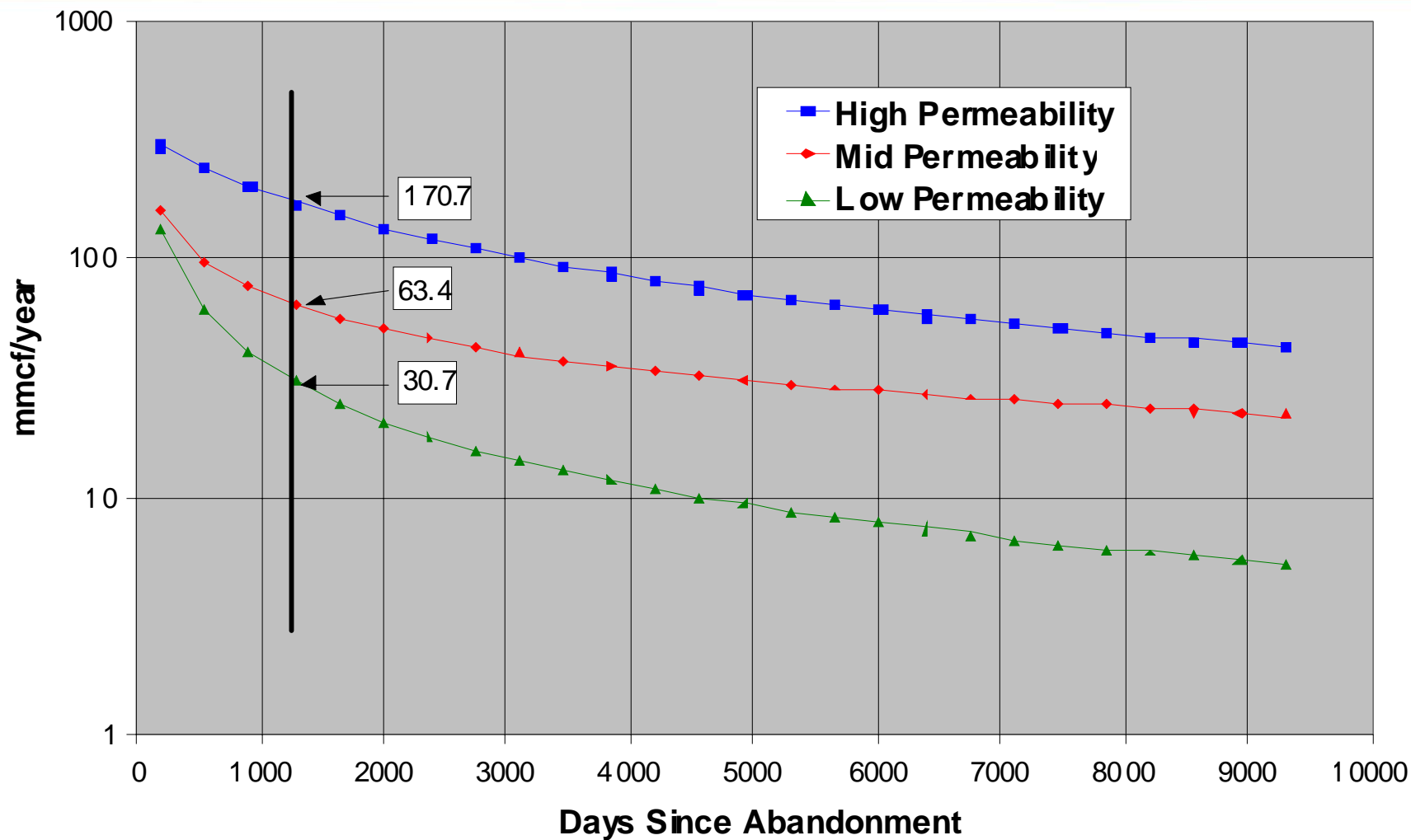
Cambria Mine gob well decline curve



Typical adsorption isotherms as a function of coal rank (GRI, 1996)



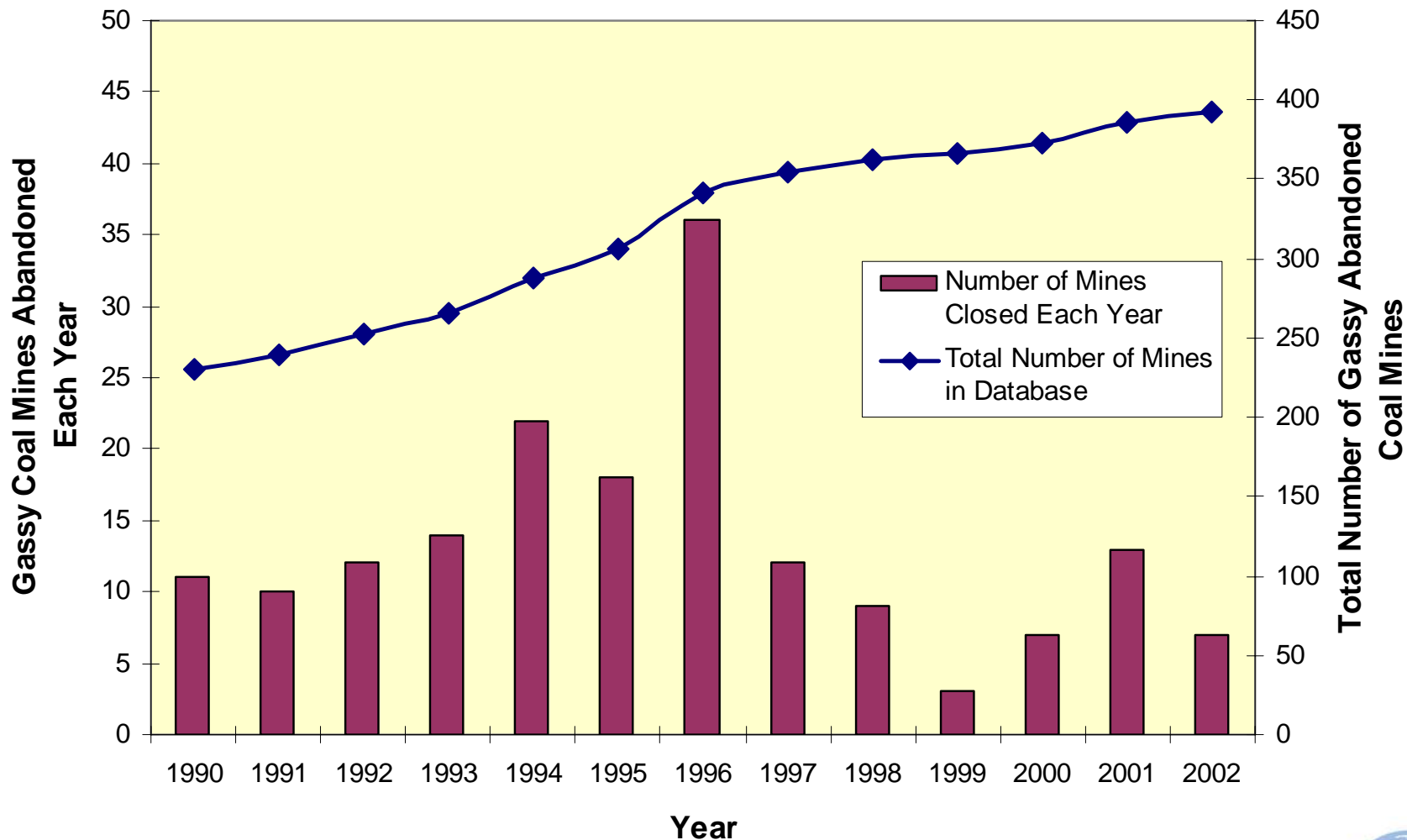
Single Abandoned Mine Emissions Through Time Based on Permeability Uncertainty



U.S. Abandoned Mine Project Opportunities

Basin	Mine Name	Estimated Emissions at Abandonment (mmcf/day)	Estimated Power Generating Capacity (MW)*	Estimated Pipeline Sales Potential (mmcf/year)*
Sanborn Creek/Hawk's Nest Complex				
Piceance	Sanborn Creek	5.0	1.4	133.4
Piceance	Hawk's Nest	1.5		
Piceance	Bowie No. 1	0.11	0.2	20.9
Willow Creek/Kenilworth Complex				
Uinta	Willow Creek	2.0	0.5	52.2
Uinta	Kenilworth	0.75		
Jefferson County Complex				
Illinois	Orient 3	1.50	0.4	36.9
Illinois	Orient 6	0.70		
Illinois	Nasson 20	0.23		
Macoupin County Complex				
Illinois	Little Dog	0.10	0.05	4.4
Illinois	Superior 1	0.11		
Illinois	Superior 2	0.08		
Illinois	Superior 3	0.11		
Illinois	Superior 4	0.07		
Illinois	Baker**	1.51	0.3-0.4	25.0-34.9

Gassy Coal Mines Abandoned Annually (1990-2002)



AMM Methodology

- In 2006, an estimated 6.7 million metric tons CO₂e of AMM were emitted in the US
- Emissions from abandoned mines are calculated according to the 2004 EPA document, “Emission Inventory Methodology and 1990-2002 Emissions Estimates.”
- Coal basin-specific geological data and coal mine-specific emission data were used to develop input parameters for a numerical model.
- Decline curves were then used to forecast abandoned mine methane emissions as a function of time since the mine was abandoned, given the characteristics of a specific coal basin.

AMM Methodology

- A series of field measurements were conducted at seven abandoned mines across the country to calibrate and test the accuracy of the decline curves
- Once decline curves were developed, emission estimates of each mine were calculated according to their status: venting, flooded, sealed, or unknown, and according to which coal basin the mine is located
- To arrive at a total abandoned mine emission inventory in a given year, Monte Carlo simulations were used to sum the probability distributions for the mines within each basin, and then to sum the emission distributions for the basins.

AMM Methodological Issues: Emissions Avoided

- Estimating annual emissions avoided at abandoned mines with recovery projects consists of two key steps:
 1. Calculating the estimated emission rate without the recovery project, and,
 2. Subtracting the project-specific emissions estimate for individual mines as appropriate.

Total annual “avoided” emissions =

annual total assuming no recovery projects - total project-specific emissions.

- Emissions avoided values do not represent the amount of gas produced from each project, but rather the amount of emissions that would have occurred had the project not been in place.

AMM Summary

Opportunities:

- Many to recover and utilize methane from abandoned (closed) mines
- Additional mines closed every year

Challenges:

- Identifying owner and acquiring rights, particularly for mines closed before 1972
- Predicting future gas resources over time

For more information:

- U.S. Abandoned Mine Profiles

http://www.epa.gov/coalbed/docs/cmm_recovery_opps.pdf

- U.S. Abandoned Mine Database

http://epa.gov/coalbed/docs/amm_final_report.pdf

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